



**Calhoun: The NPS Institutional Archive**  
**DSpace Repository**

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CRUSER (Consortium for Robotics and Unmanned Systems Education and Research)

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2017-04-11

# Robodata Archive for Visualizing CRUSER Unmanned System Field Experimentation [video]

Brutzman, Don

Naval Postgraduate School, Monterey, California

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<http://hdl.handle.net/10945/53350>

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**Dudley Knox Library / Naval Postgraduate School**  
**411 Dyer Road / 1 University Circle**  
**Monterey, California USA 93943**

<http://www.nps.edu/library>

*Robodata.nps.edu*

Unmanned System Data Archives

Project Support for NPS Field Experimentation (FX)

Don Brutzman

Information Sciences (IS) Department  
Undersea Warfare Academic Group (USWAG)

4 April 2017

# Overview

[robodata.nps.edu](http://robodata.nps.edu)

# Objectives

## Background

- Bootstrap a short course to expose initial capabilities, if approved
- Evaluate course suitability, provide recommendations for further work

## Current

- Scale across/outside campus to support JIFX experimentation, Camp Roberts
- Build a growing institutional data archive

## Long term

- Ensure that every NPS experiment with unmanned systems is archived and reusable
- Enable steadily improving analysis, insights, applications and data-driven progress
- Influence, align with broader DoD and scientific practice

# CRUSER

- Consortium for Robotics and Unmanned Systems Education and Research ([cruser.nps.edu](http://cruser.nps.edu))
- NPS leverages long-standing experience and expertise in research and education of robotics and unmanned systems to support the Navy's mission.
- CRUSER serves to align disparate research efforts and also integrate academic courses across disciplinary boundaries.



# JIFX: Joint Interagency Field Experimentation

- Held quarterly, usually at Camp Roberts
- Run robots in controlled airspace/playpen
- Open to industry and external academia, each self supporting
- Experimentation, not exercise: includes freedom to fail and learn
- Established ~5-year program with DoD sponsorship
- Closely affiliated with CRUSER



# Applying an Operational System from MBARI



## to Establish New Capabilities at NPS

Database Alias	Name	Description	Start (GMT)	End (GMT)	Platform count	Parameter count	Activity count	MP count	SP count	Loading Time
default	<a href="#">Initial Test Database</a>	Post-setup load of a variety of data to use for testing	27 Oct 2010 21:04:19	28 Oct 2010 23:34:19						



# STOQS

## Spatial Temporal Oceanographic Query System

### Inputs

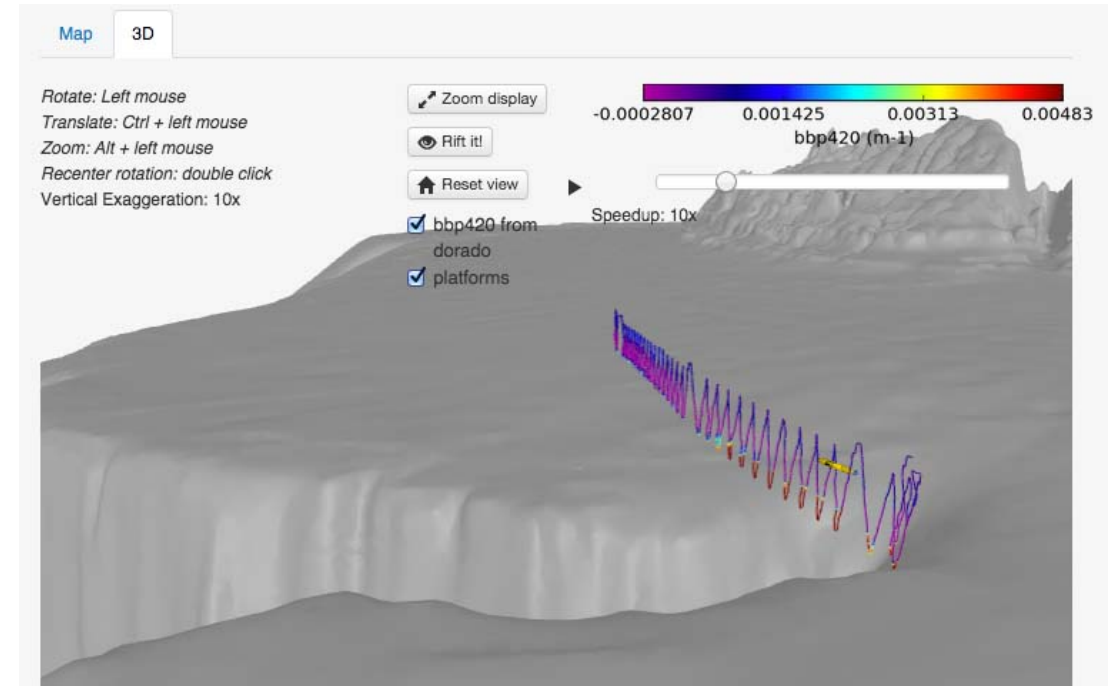
- Diverse robots, sensors and systems
- Collected air, surface, subsurface data
- Precise metadata tags, scientific terms

### Outputs

- Queries, filters and mashups
- Data plots, 2D maps, 3D views

### Learn more

- [STOQS home page](#) and [paper](#)
- [STOQS overview video](#)
- [Online query](#) and [open source](#)



Can view 3D flythrough in Web browser





M B A R I

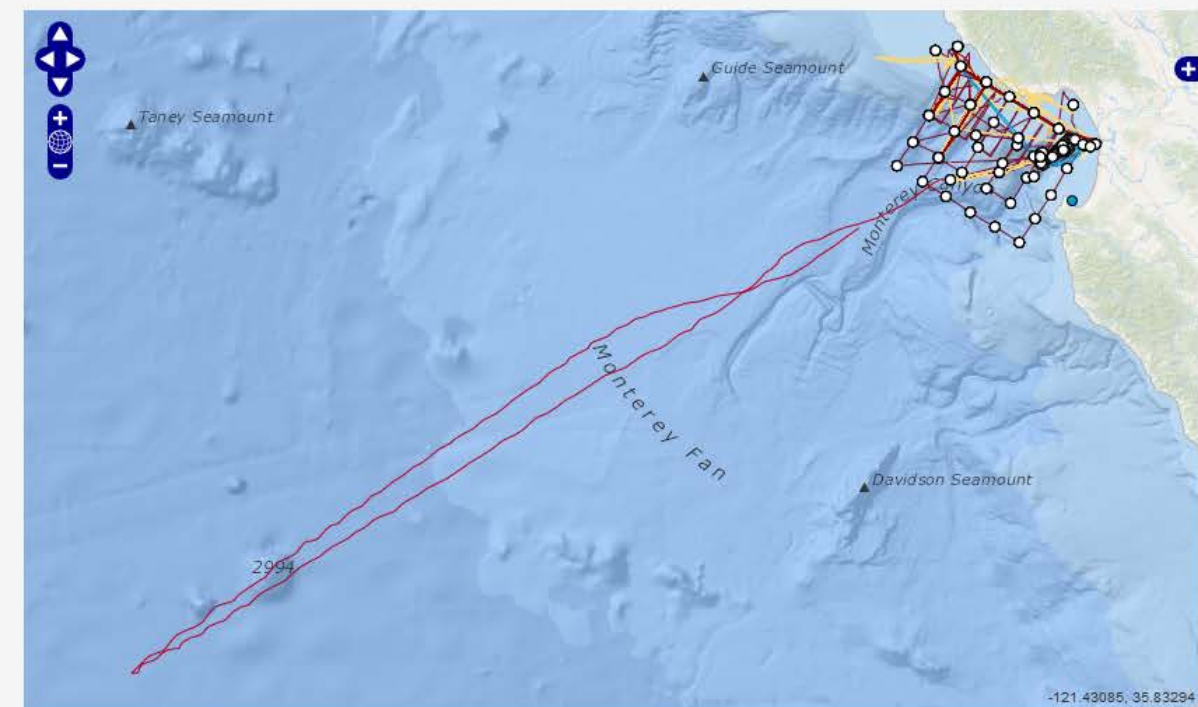


0:27 / 2:48



## Spatial

Map 3D



☒ Zoom to extent on update

**Metadata:** about 21,303,321 data values - 2.688 seconds

**Parameter-Parameter** [Clear Selection](#)

**Measured Parameter Data Access**

**Temporal:** 2015-09-09 20:11:46 to 2015-10-16 00:00:00 [Clear Selection](#)

Depth: -4.04 to 1002 [Parameter](#)

Click and drag to zoom

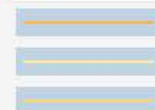


**Measured Parameters** [Clear Selection](#)

**Parameter Values** [Clear Selection](#)

**Platforms** [Clear Selection](#)

auv



daphne

dorado

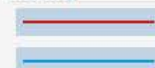
tethys

glider



SPRAY\_L66\_Glider

mooring



M1\_Mooring

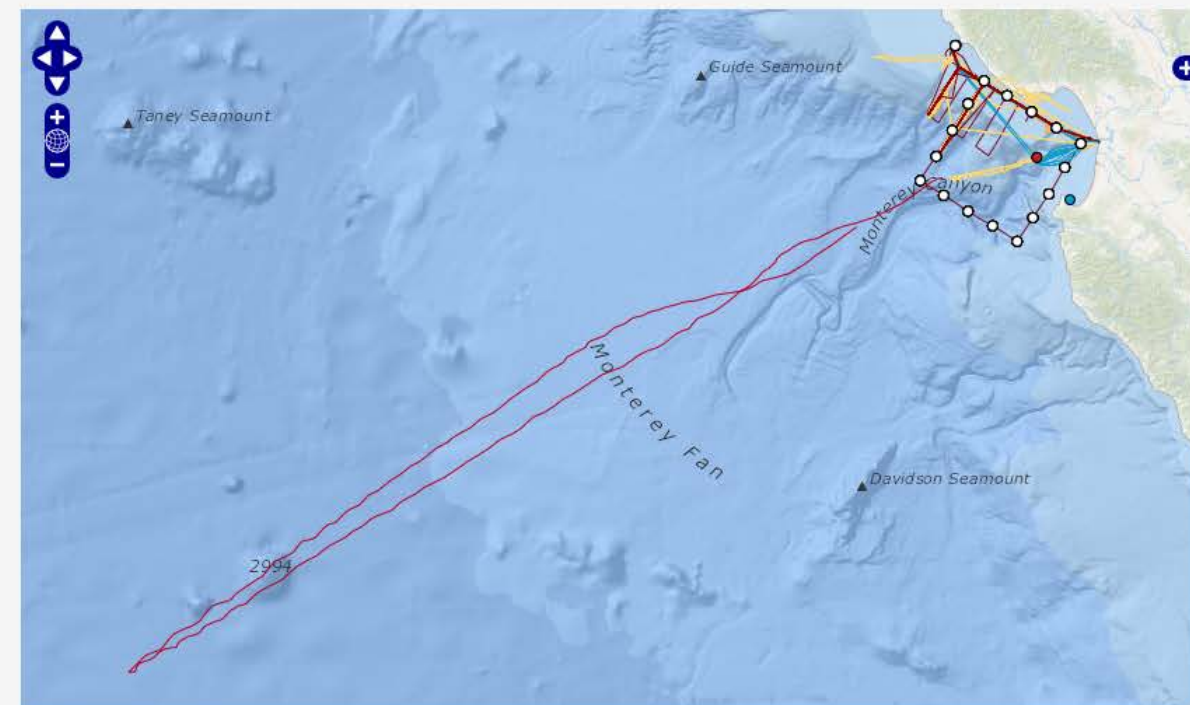
OA1\_Mooring

Can view 2D maps and data graphs



## Spatial

Map 3D



☒ Zoom to extent on update

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**Parameter-Parameter** [Clear Selection](#)

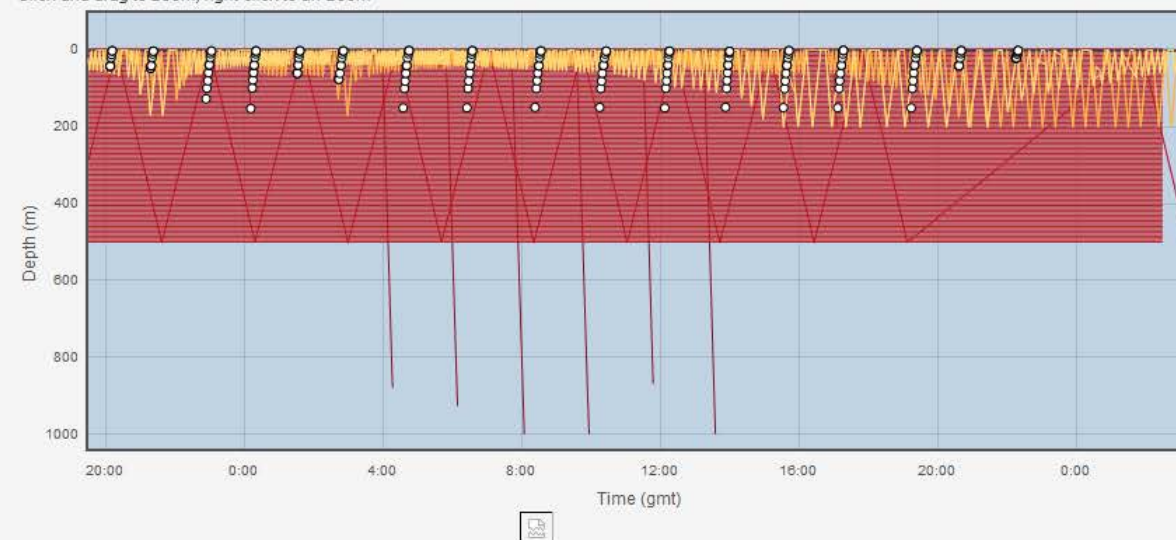
**Measured Parameter Data Access**

**Temporal:** 2015-09-30 19:29:48 to 2015-10-02 03:13:56

[Clear Selection](#)

Depth: -96.46 to 1037.94 [Parameter](#)

Click and drag to zoom, right-click to un-zoom



## Measured Parameters

[Clear Selection](#)

☐ Show Parameter-Parameter ☐ Show coordinates ☐ Filtered out parameters ☐ Standard Names

[Filter & Select for data access](#)

### Plot Data

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<input type="radio"/>	air_temp	<a href="#">i</a> <a href="#">[icon]</a>
<input type="radio"/>	AIR_TEMPERATURE_HR	<a href="#">i</a> <a href="#">[icon]</a>
<input type="radio"/>	altitude	<a href="#">i</a> <a href="#">[icon]</a>
<input type="radio"/>	atm_press	<a href="#">i</a> <a href="#">[icon]</a>
<input type="radio"/>	avg_wind_spd	<a href="#">i</a> <a href="#">[icon]</a>
<input type="radio"/>	bb470	<a href="#">i</a> <a href="#">[icon]</a>
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<input type="radio"/>	bb_650	<a href="#">i</a> <a href="#">[icon]</a>
<input type="radio"/>	bb676	<a href="#">i</a> <a href="#">[icon]</a>



# Making data useful

(subtitle: making data not suck!)

## Dataset collection conventions

- Precise timestamps, locations, measurements. Scrubbing, cleanup. “It is what it is.”
- Validation of correctness, schemas if possible, pay attention to units and conversions.
- Unambiguously describe the meaning of each data value with type and metadata.
- Adding narrative data: exercise logs, operator comments, images, ephemera.
- Logging, archiving, network access, security considerations, backups.

## Metadata vocabularies

- Strictly defined nomenclatures and data-dictionary definitions, specialized as appropriate for each community of interest. Examples: oceanography, meteorology.
- Community of practice that governs standardization, adoption and evolution.

## Success metrics

- Exploration, analysis, re-use, comparisons, publication, insight, understanding
- Big Data Mashups!

# Related NPS work: recorded datasets, outputs

- Shelley Gallup's FIRE database for Trident Warrior exercise data capture
- Core Lab suite of Defense Analysis tools
- Operations Research SEED Center
  - Large datasets produced by clusters, computational modeling & simulation
- MOVES Savage tool suite for 3D models
  - X3D model archives, Autonomous Unmanned Vehicle (AUV) Workbench
  - X3D-Edit authoring, visualization using simkit Discrete Event Simulation (DES)
- ARSENL lab data/video records of swarm simulations, experiments
  - ... and still more? Please tell us about it!

No doubt additional NPS activities will emerge, this is a common need

# Complex Systems Field Experimentation: objectives, activities and lessons learned

- “You get what you measure” - deciding on data to record not only produces information, but also establishes feedback loops and progressive refinement on areas that are get focused attention
- Experimental design shows *intention*
  - What are the questions that your project is pursuing?
- From engineering and analysis perspective: Data is Design
  - Mashups and “big data” initiatives become practical
  - Paul Pappas, “[How Big Data Is Revolutionizing Design](#),” WiReD, November 2014

# Looking ahead



# Designing for future evolution

- Growing collection of datasets over years and different locations
- Scientific basis so that all data values are well defined for long term
- Repeatable “business model” fully aligned with institutional practices
- Useful for emerging, evolving Big Data activities
- Real-world approaches adaptable to simulation outputs
- Questions/analysis/answers for naval robotics is not so different from assessment of actual ships and aircraft deployed in the real world
- Partnership with MBARI might grow to include other participants
- Supports [Department of Navy Innovation Goals](#) for Data-Centric Navy



## INNOVATION ELEMENT 3: TRANSFORM HOW THE DON USES INFORMATION

The Department of the Navy collects more data each day than the total amount stored in the Library of Congress. Yet, the DON is organized and funded around systems and hardware and lacks the tools to ensure the information is used to its full potential. DON organizations dedicate time and resources to turn their data into useful information, then face institutional bottlenecks in sharing that information, vastly restricting its value.

The DON recognizes that information is a strategic asset which empowers people to make informed decisions. Sharing information across organizational boundaries enables innovation to thrive. The DON will integrate technology and learn from other organizations' best practices to maximize the value of our existing information and become a learning organization by mastering the information cycle.

"Someday, on the corporate balance sheet, there will be an entry which reads, 'Information'; for in most cases, the information is more valuable than the hardware which processes it." - Rear Admiral Grace Hopper



### KEY OBJECTIVES:

- Become a Data-Centric DON
- Develop an Advanced Analytics Agenda
- Increase Agility in Training and Acquisition Processes
- Build Analytics Expertise and Certification Pathways
- Reduce the Burden Associated with Sharing Information

All key objectives supported

# Working to establish NPS institutional support

## Relevance to NPS educational objectives and research deliverables

- Catalog entries being prepared for Calhoun library archive search

## Partnered support to establish system by multiple NPS stakeholders

- Information Sciences (IS) Department, JIFX/CRUSER, NPS Research Office, ITACS network infrastructure, Dudley Knox Library Calhoun Archive, others
- White paper available for review, discussions in progress

Feedback, participation from participants & users always welcome

# Work in progress

Starting to connect first few unmanned systems experiments from JIFX in early August 2016

Installing, testing local copies of STOQS open source

- robodata.ern.nps.edu (and eventually local copy at Camp Roberts when testing)

Adapt data-upload modules to NPS robots, prepare short-course module

- Developmental testing this time, production requirements/capabilities next time

Photographic and video recordings will be handled separately

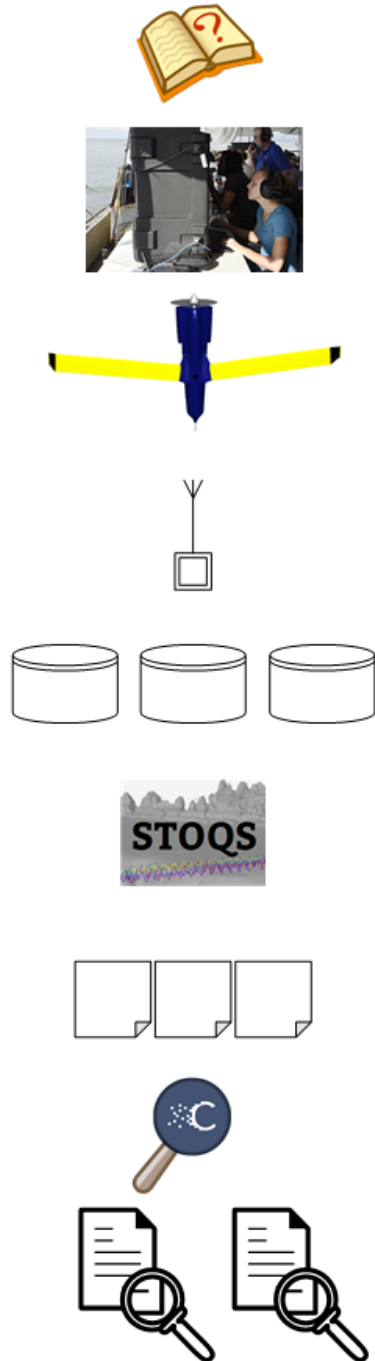
- Media, storage, serving and playback requirements are quite different
- Shared need for common, cross-linked time/position/metadata annotations

Evaluate whether NPS publication-review rules sufficiently address data

- Acceptable open-source licenses; participation invitation
- Access restrictions: someday For Official Use Only (FOUO) on nps.navy.mil

# Preparing robot mission data and metadata

Robodata  
information  
flow  
provides a  
repeatable  
pattern



Schema data design: value types and metadata

Operator defines mission plan, records summary

Robot collects, records sensor data

Relay, transfer data to intermediate storage

Archive all data: telemetry, imagery, video, 3D

Convert telemetry, load “big data” in STOQS

Operators verify mission logs, narrative, links

Publish catalog entries to Calhoun for search

Query, compose, analytics mashups, re-use, etc.

# Contributing data

Interested? We're keen to work with your team.

Please email [robodata@movesInstitute.org](mailto:robodata@movesInstitute.org) with as much of the following information as possible.

- Robot name, type, configuration and identifying information
- Experiment goals and outcomes
- Location, date, times
- Sensor types
- Telemetry data files
- Images with captions, date/time/location
- 3D models (we will convert into X3D for Web use)
- Video availability

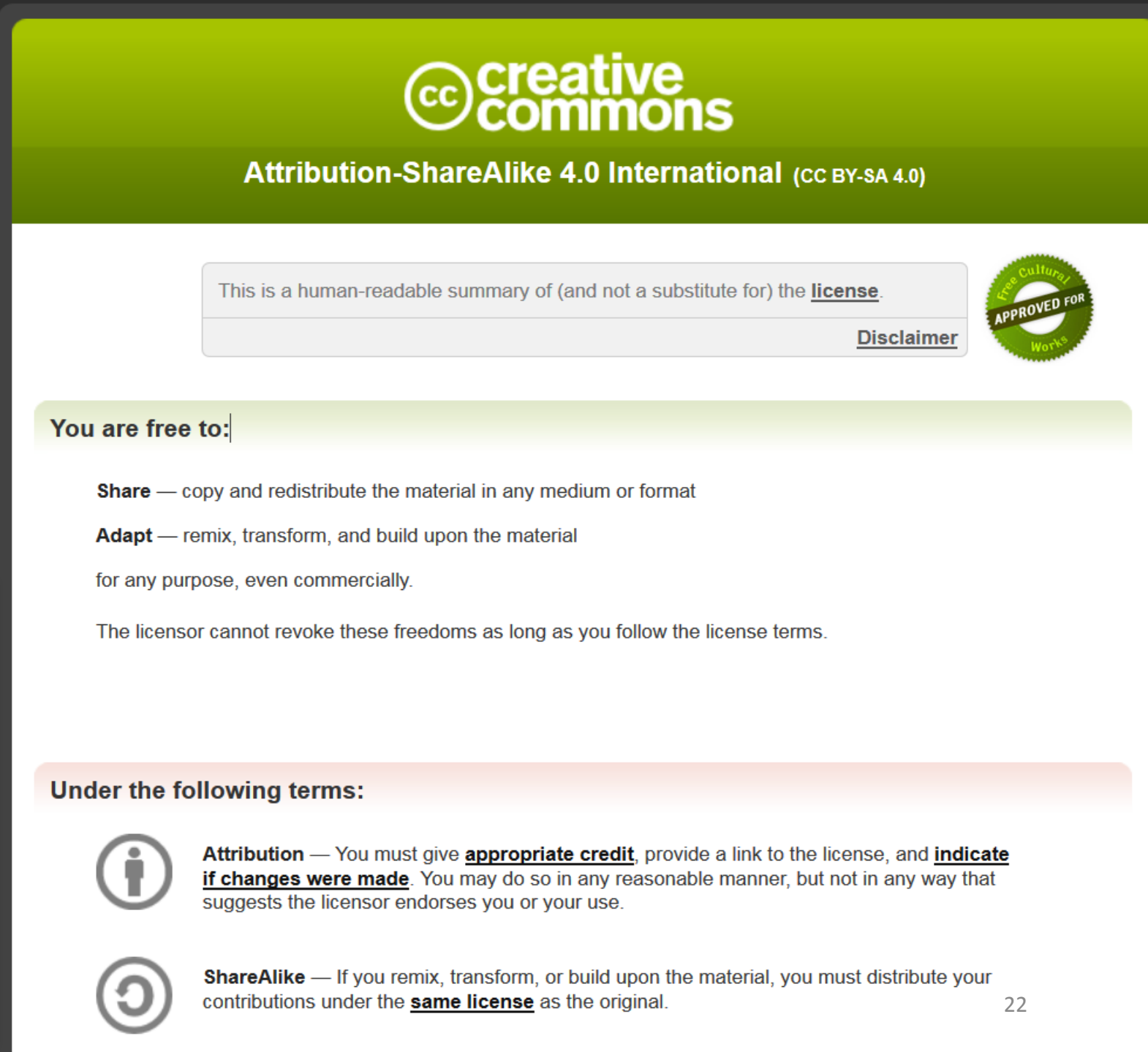


# Open-Source Data Licenses


Suggested:

- **Creative Commons Attribution-ShareAlike 4.0 International**
- **[\(CC BY-SA 4.0\)](https://creativecommons.org/licenses/by-sa/4.0/)**

Other open-source  
licenses are acceptable




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# Questions for users – all feedback welcome!

What data does your unmanned system record?

- Data type, metadata classification, timing, location, purpose

Do you have past archives of data available?

Do you want to configure an active system to feed robodata archive?

What additional requirements and goals do you have?

**Solution approach: multiple surveys with IRB compatibility**



## Robodata

[Robodata Welcome](#) [Robots](#) [Data](#) [Metadata](#) [Share](#) [Visualize](#) [About ▾](#)

## Metadata



[Metadata](#) is about forms of data relating to other data. For example, metadata can provide a variety of information regarding a document such as author, date revised, relevant key words, etc.

Metadata is crucially important for describing collected data, supporting search, and enabling mashups to create new information.

## Mission Metadata Requirements

The following metadata is needed for any meaningful mission data collection effort:

- *Mission information.* Who, what, when, where, why and how.
- *Telemetry datasets.* The raw data, as collected or in compressed form.
- *Telemetry metadata.* Precise details are needed for each sensor measurement including units, configuration, etc.
- *Images and captions.* What does each picture mean? Tell the viewer what it means.
- *Video recordings.* Short clips or links are accepted. Include start/stop times, location (or correlation to robot-location track), etc.

Current work includes definition of a series of survey forms to facilitate data collection and metadata archiving by robot operators.

## Archival Access

It is possible to document "what data was collected?" in precise, searchable ways. We are able to export database information as [precise metadata terms](#) to produce search-accessible catalog entries for the [Calhoun Institutional Archive](#) at NPS Dudley Knox Library.

The key to all unmanned systems data-collection efforts is proper annotation of metadata. This is a fundamentally important task. Once procedures and operational processes are in production and tested satisfactorily, we are next looking at publishing resource catalog metadata as part of the [Defense Technical Information Center \(DTIC\)](#) collections.



# Metadata exemplar

## Joint Interagency Field Experimentation (JIFX) 16-4 Robodata



### Abstract

The robodata project is collecting telemetry and mission information from a wide variety of robots at the Joint Interagency Field Experimentation (JIFX) event being held at Camp Roberts, CA 8-11 August 2016. Project Website: <https://my.nps.edu/web/robodata>. Robodata Repository: <https://robodata.ern.nps.edu>. Reference: <http://stoqs.mbari.org>. JIFX 16-4: <http://my.nps.edu/web/tx/jifx-live>.

### URI

<http://hdl.handle.net/10945/49617>

View/Open



JIFX\_6-4\_2016-08-08.pdf

(33.66Kb)

Download Record

[Download to EndNote/RefMan \(RIS\)](#)

[Download to BibTex](#)

### Collections

Datasets Collection

Faculty and Researcher Publications Collection

<https://my.nps.edu/web/robodata/metadata>

## Joint Interagency Field Experimentation (JIFX) 16-4 Robodata

dc.contributor.author	Brutzman, Don	
dc.contributor.author	McGregor, Don	
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dc.description.abstract	The robodata project is collecting telemetry and mission information from a wide variety of robots at the Joint Interagency Field Experimentation (JIFX) event being held at Camp Roberts, CA 8-11 August 2016. Project Website: <a href="https://my.nps.edu/web/robodata">https://my.nps.edu/web/robodata</a> . Robodata Repository: <a href="https://robodata.ern.nps.edu">https://robodata.ern.nps.edu</a> . Reference: <a href="http://stoqs.mbari.org">http://stoqs.mbari.org</a> . JIFX 16-4: <a href="http://my.nps.edu/web/tx/jifx-live">http://my.nps.edu/web/tx/jifx-live</a> .	en_US
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# Contact

**Don Brutzman, Ph.D.**

[brutzman@nps.navy.mil](mailto:brutzman@nps.navy.mil)

[brutzman@nps.navy.smil.mil](mailto:brutzman@nps.navy.smil.mil)

<http://faculty.nps.edu/brutzman>

Code USW/Br, Naval Postgraduate School

Monterey California 93943-5000 USA

1.831.656.2149 work

1.831.402.4809 cell

# Contact

**Don McGregor**

[mcgredo@nps.edu](mailto:mcgredo@nps.edu)

Modeling Virtual Environments Simulation (MOVES) Institute

Code MV/Mc, Naval Postgraduate School

Monterey California 93943-5000 USA

1.831.656.7605 work

# Design Thinking and robot data



# Designing a Short Course for Creating Robotics Data Archives

NPS DA4500 Design Brief

Don Brutzman, Ann Gallenson, Shelley Gallup

June 2016

# Objectives

## Background

- Bootstrap a short course to expose initial capabilities, if approved
- Evaluate course suitability, provide recommendations for further work

## Current

- Scale across/outside campus to support JIFX experimentation, Camp Roberts
- Build a growing institutional data archive

## Long term

- Help NPS become a design-competent organization
- Influence, align with broader DoD and scientific practice

# Project goal: given a short course, show students how to apply design thinking

Background: creating a new short course to utilize a system that supports ongoing needs and emerging capabilities in data capture.

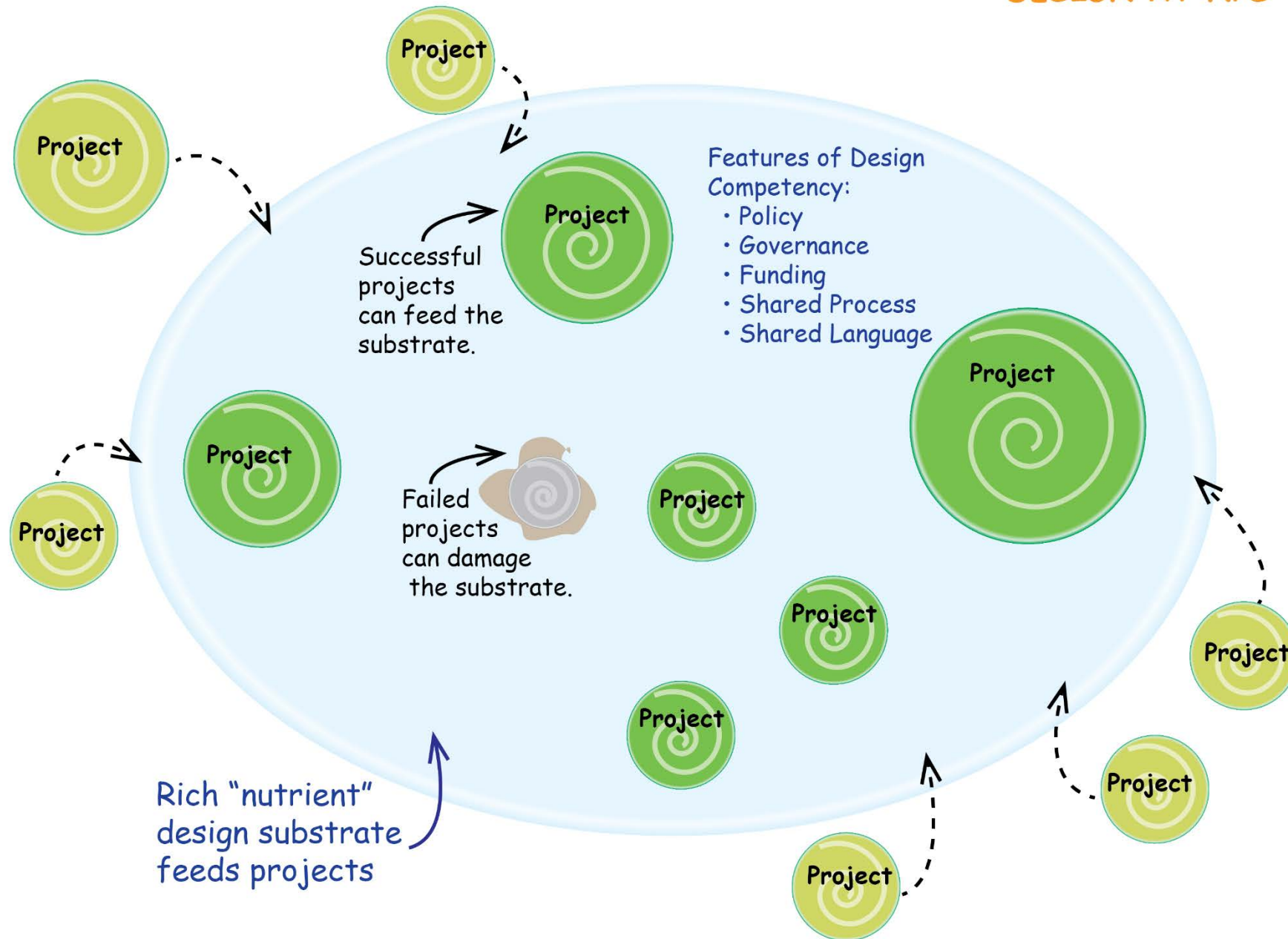
- Course shows how to plan, prepare, contribute and utilize datasets in the online archive.

Need to show how design thinking can be applied within any student project involving the collection and interpretation of data collected by robots or other unmanned systems.

# Motivations

- Expose many individuals at NPS to process of design thinking
- Create data products that themselves are building blocks for ongoing design mashups and assessments
- Better data produces better understanding
- Not try to be all things for all people, but apply design principles well within a given context that has broad implications and connections

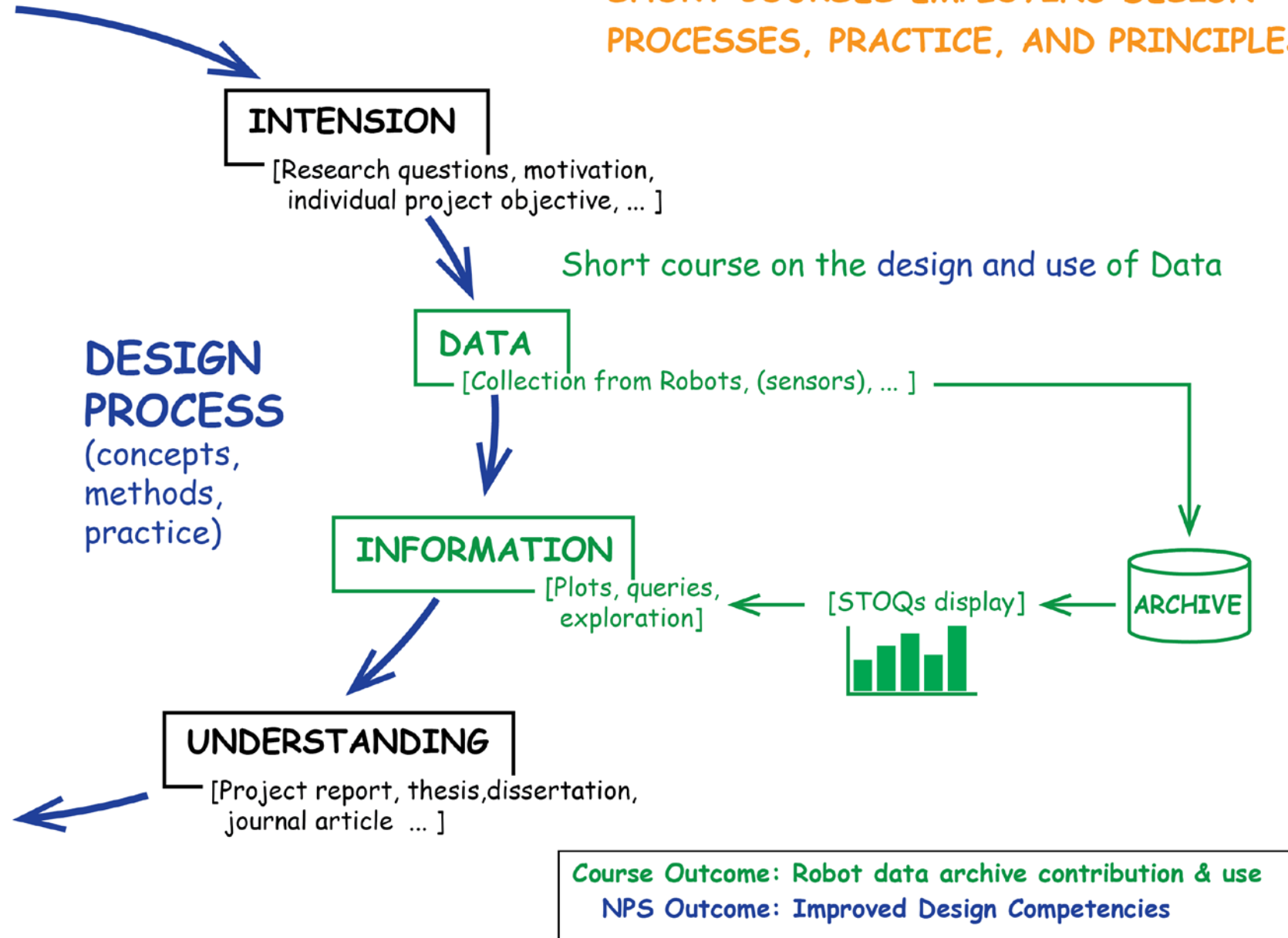
## DESIGN AT NPS



# Course syllabus: initial outline

- Establish your project motivation, goals, and critical research questions
- Experimental design
  - What measures and scenarios answer the questions of interest?
  - List robot and sensor assets available, desirable
  - Data design: sensors availability, how to collect it, assigning correct metadata
- Data archive mechanics
  - How to use STOQS to display collected robot data for evaluation and analysis
  - How to log, extract, massage, and upload your system data into NPS archive
- Practical exercise
  - Work with prepared data (from course or student project), create report

## SHORT COURSES EMPLOYING DESIGN PROCESSES, PRACTICE, AND PRINCIPLES





# Relation to John Arquilla “Sponsor” Vision for Defense

- DoD operations are increasingly unmanned
- Data-driven evaluation of robotic systems is cross-cutting necessity
- Opportunity: exploding availability of sensors, Internet of Things (IOT)
- Humans have difficulty evaluating what they can't see or measure
  - “Captain, how did your team do out there?” versus “what happened to the robot?”
- Deluge of data needs to be transformed into coherent information that effectively informs judgements and decisions (both human and artificial)

Bottom line:

- Adapt NPS activities to understand changing nature of modern warfare
- Foster design competencies in NPS course work and research projects

# Sections of a Design Brief

1. agency (i.e. decision makers, stake holders, etc.)
2. intension / direction or strategy for approach
3. systems assessment (i.e. context, environment, elements etc.)
4. establishing limits or boundary / enabling judgments (i.e. priorities,
5. defining performance specifications (i.e. outcomes of good design)

## **intention - outcomes**

6. defining prescriptive specifications

## **Designing (not part of brief)**

7. concept development
8. design development
9. realization

# Agency: decision makers and stake holders

- **Students:** course work and capstone/thesis investigation
  - **Faculty:** course assignments, research experimentation projects
  - **NPS:** pedagogy, research support, institutional archive, mission
- 

- Sponsors: reusable record of project results
- Partners
  - Capture results from NPS JIFX field experimentation
  - Share data compatibly with other universities and groups
- Navy and DoD
  - Mandates: Data-centric Navy, Data.gov imperatives
  - Good practices worth repeating will continue to improve

# intension / direction or strategy for approach: **design a short course**

## Demonstrate mechanics of simple data collection

- Overview of STOQS system: capabilities, products, prerequisites
- Mechanics of collecting/converting simple sample series to build data sets
- Assigning proper metadata to data items, including timestamp and location
- Uploading annotated data stores into the archive
- Performing data analysis using online tools: graph plots, 2D maps, 3D flythrough

## Communicate design principles for common tasks

- Define objectives and goals for a given robotics project
- How to develop key questions that support objective exploration
- Figuring out how their robot data can support answering those key questions

# systems assessment (i.e. context, environment, elements etc.)

## Context

- Frequent reinvention of common task with poor results, then assets are lost
- Strategy thumbrule: “We all know how this plays out. How do we get there?”

## Provenance

- MBARI has produced open-source system answering most of our technical needs
- NPS has mission goals and many stakeholders needing better support

## Environment

- Modest budget: open source, high-tech infrastructure already available, sustainable
- Competence: skilled champion MBARI for support, repeatable demonstrated system

## Elements

- Students and faculty running robotic data-collection systems need support
- Assume initial STOQS capability gets installed, becomes operational at NPS

# establishing limits or boundaries, enabling judgments (i.e. priorities)

- Keep expectations well scoped to what system can accomplish today
- “Good data” is definable, supportable based on existing exemplars
- Limited time available to course participants
  - Only half-day/full-day tutorial is currently practical
  - Keep It Simple Smartypants (KISS principle) with ongoing spiral improvement
- Understanding data results is a process that comes from well-defined questions, open examination and iterative improvement
  - Scientific method combined with scholarly inquiry, not a checklist
- Technology is an enabler, not end goal or “silver bullet” per se
  - Example: VR headset may help understanding but is not the end objective

# defining performance specifications (i.e. outcomes of good design)

- Course goals, design rationale and syllabus
- Ready to prepare initial course supporting JIFX, NPS quarterly break
- Participants can apply material immediately after course completion
- Student projects and theses presented in live forum, also archived
- Iterative process: share lessons learned, encourage exploration
- Second/third pass: record class video to support study at any time
- Expectation: advanced and complementary course work will follow

# Design is relevant at multiple levels of context

- Supporting role: creation of new course to support students
- **Teach design principles for participants to apply in their projects**
- Designing for success: possibility of scaling up or adapting over time

Careful to identify specific context  
when discussing relevant design points



# Feedback welcome 😊

- Questions and improvements please

# Contact

Don Brutzman	Ann Gallenson	Shelley Gallup
<p>Code USW/Br Information Sciences (IS) Dept. Naval Postgraduate School (NPS) Monterey CA 93933-5000</p> <p><a href="mailto:brutzman@nps.edu">brutzman@nps.edu</a> 831.656.2149</p>	<p>Center for Executive Education (CEE) Naval Postgraduate School (NPS) Monterey CA 93933-5000</p> <p><a href="mailto:acgallen@nps.edu">acgallen@nps.edu</a></p>	<p>Code IS/Ga Information Sciences (IS) Dept. Naval Postgraduate School (NPS) Monterey CA 93933-5000</p> <p><a href="mailto:spgallup@nps.edu">spgallup@nps.edu</a></p>